

Claims:

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A magnetic recording medium comprising, in sequence, on a nonmagnetic substrate, at least one soft magnetic underlayer, an orientation control layer to control the orientation of the layer immediately above, and a perpendicular magnetic layer having an axis of easy magnetization which is oriented mainly perpendicularly to the nonmagnetic substrate,

and said soft magnetic underlayer has a multilayer structure having a plurality of soft magnetic layers comprising a soft magnetic material, and one or more separation layers interposed between said soft magnetic layers, and at least one of said soft magnetic layers comprises a material with a structure having no magnetic domain walls.

2. A magnetic recording medium according to claim 1, wherein the material with a structure having no magnetic domain walls is selected from FeAlSi, FeTaN, FeTaC, FeC, FeAlSi type alloys, FeTaN type alloys, and FeTaC type alloys.
3. A magnetic recording medium according to claim 1, wherein the separation layer comprises 50 at. % or more of one of, or two or more of the elements Ru, Rh, Re, Ir, and Cu.
4. A magnetic recording medium according to claim 1, wherein the separation layer is constituted of a soft magnetic material that is different from the material constitutions the soft magnetic layers between which the separation layer is interposed.
5. A magnetic recording medium according to claims 2, wherein the product $B_s \cdot t$ (T · nm) of the saturation magnetic flux density per layer B_s (T) of the soft magnetic layer and the thickness of the soft magnetic layer t (nm), is 3 T · nm or more for each of the soft magnetic layers.
6. A magnetic recording medium according to claims 2, wherein the magnetic flux density of the soft magnetic layer is 0.4 T or more.

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A magnetic recording medium according to claims 2, wherein the thickness of the soft magnetic underlayer is 40 nm or more.

8. A magnetic recording medium according to claims 3, wherein the thickness of the separation layer is in the range from 0.1 nm to 5 nm.

9. A magnetic recording medium according to claims 1, wherein among sets of an upper and a lower soft magnetic layers between which the separation layer is interposed, at least one set has different directions of magnetization for the upper and lower soft magnetic layers.

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10. A magnetic recording medium according to claims 1, wherein among sets of an upper and a lower soft magnetic layers between which a separation layer is interposed, at least one set has directions of magnetization which are antiparallel.

11. A magnetic recording medium according to claim 10, wherein the direction of the magnetization of the soft magnetic layer is along the radius of the nonmagnetic substrate and oriented towards the periphery of the substrate or towards the center of the nonmagnetic substrate.

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12. A magnetic recording medium according to claims 1, wherein a hard magnetic layer is formed between the nonmagnetic substrate and the soft magnetic underlayer, and the magnetization of said hard magnetic layer is directed along the radius of the substrate and towards the periphery or the center of the substrate, and bonded with the magnetization of the soft magnetic layer which is the lowest layer of the soft magnetic underlayer.

13. A magnetic recording medium according to claims 1, wherein the lowest layer of the soft magnetic underlayer comprises a material of one selected from the group consisting of FeAlSi, FeTaN, FeTaC, FeAlSi type alloys, FeTaN type alloys, and FeTaC type alloys.

Surface Control

14. A magnetic recording medium according to claims 1, wherein the top layer of the soft magnetic underlayer is a soft magnetic layer.

15. A magnetic recording medium according to claims 1, wherein a part of the surface or all of the surface of the soft magnetic underlayer nearest the perpendicular magnetic layer is oxidized.

16. A method for producing a magnetic recording medium by forming, on a nonmagnetic substrate, at least one soft magnetic underlayer, an orientation control layer for controlling the orientation of the layer immediately above, a perpendicular magnetic layer having an axis of easy magnetization which is oriented mainly perpendicularly to the substrate, with the soft magnetic underlayer having a multilayer structure having a plurality of soft magnetic layers comprising a soft magnetic material, and one or more separation layers interposed between said soft magnetic layers, and one of more of the soft magnetic layers comprises a material with a structure having no magnetic domain walls.

17. A method for producing a magnetic recording medium according to claim 16, wherein the material with a structure having no magnetic domain walls comprises one selected from the group constituting of FeAlSi, FeTaN, FeTaC, FeC, FeAlSi alloys, FeTaN alloys, and FeTaC alloys.

18. A method of producing a magnetic recording medium according to claim 17, wherein the magnetization of the soft magnetic layer is directed along the radius of the nonmagnetic substrate towards the periphery or the center of the nonmagnetic substrate.

19. A method for producing a magnetic recording medium according to claims 17, wherein a treatment for oxidizing the surface of the soft magnetic underlayer is included.

Surface Control

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20. A magnetic recording and reproducing device comprising a magnetic recording medium having at least nonmagnetic substrate, a soft magnetic underlayer, an orientation control layer to control the orientation of the layer immediately above it, and a perpendicular magnetic layer having an axis of easy magnetization which is oriented mainly perpendicularly to the nonmagnetic substrate, and a magnetic head for carrying out recording and reproducing of the information to and from the magnetic recording medium, the soft magnetic underlayer of the magnetic recording medium being formed with a multilayer constitution having a plurality of soft magnetic layers comprising a soft magnetic material, and one or more separation layers interposed between the soft magnetic layers.

21. A magnetic recording and reproducing device according to claim 20, wherein the material with a structure having no magnetic domain walls comprises one selected from the group consisting of FeAlSi, FeTaN, FeTaC, FeC, FeAlSi type alloys, FeTaN type alloys, and FeTaC type alloys.